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Mapping urban ecology education in the UK

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Abstract

Urban ecology has matured as a field of investigation. This paper explores how well it has transitioned into the educational curricula of UK Higher Education Institutions (HEIs) by mapping the presence of urban ecological or environmental topics across undergraduate and postgraduate programmes. The prevalence of different topics, the level at which they are taught, and the disciplinary areas in which they are housed, are quantified. Urban ecological topics are found in programmes across 50 of 147 HEIs (34%), mainly taught in ancillary fashion to support wider subjects, though some specialist modules and even programmes do exist. Only one HEI incorporates a compulsory (core) dedicated urban ecology module at undergraduate level. Much urban ecology teaching takes place at advanced undergraduate and postgraduate levels. Applied topics are usually taught from an environmental science perspective, with common examples including urban hydrology, climate and green infrastructure; probably to address global concerns about urban sustainability and resilience. In particular there is scope for greater incorporation of urban ecology topics and themes into biological and ecological programmes, and utilising cities as labs to explore these topics. The paper concludes with a discussion of some of these possibilities.

Keywords: Urban; environmental science; curriculum development; cities; sustainability

Word count: 3683 (main text and references)

1. Introduction

The field of urban ecology is expanding rapidly, with substantial increases in the rate of articles being published in academic journals over recent decades. Since early work focusing mainly on the plant and animal communities of urban locations (e.g. Church 1922; Darlington 1981; Gilbert 1989), work has broadened to take in broader spatio-temporal patterns of biodiversity and ecological processes, often through the methodological framework of urban gradients (Francis et al. 2016), as well as to incorporate non-biological elements of the urban ecosystem, including climate (Bowler et al. 2010), hydrology (Fletcher et al. 2013), soils (Ossola and Livesley 2016), pollution (Beckett et al. 1998) and so on. Though the latter may be more reflective of an 'urban environmental science', all of these aspects are intrinsically linked to ecological processes and communities, and so 'urban ecology' tends to be the overarching terms used for the field of urban investigations. Wu (2014) has suggested that the field is now a 'mainstream ecological field', and that this transition has largely been achieved in the 21st century.

Importantly, urban ecology is a particularly *applied* field of enquiry, with much research focused around mechanisms for prevention, mitigation or management of urban environmental and socio-ecological problems, such as flooding, urban heat islands, loss of biodiversity, and pollution; and ultimately the development of more sustainable urbanisation (e.g. Richter and Weiland 2012; Wu 2014). Such approaches lend themselves well to interdisciplinarity (Francis et al. 2012), and urban ecology is perhaps one of the areas in which interdisciplinary work, including not just the biological, environmental and physical sciences but also the social sciences and humanities, has been particularly prevalent; often unified around transdisciplinary concepts such as sustainability, connectivity and resilience (Wu 2014; LaPoint et al. 2015; Meerow et al. 2016). Articles on urban ecology have appeared in a wide range of scientific journals in recent decades, and there are now several academic journals dedicated specifically to urban ecology and urban ecosystems, including *Landscape and Urban Planning* (est. 1986), *Urban Ecosystems* (1997)*, Urban Forestry and Urban Greening* (2002)*, Urban Water Journal* (2004)*, Journal of Agricultural and Urban Entomology* (2007) and *Journal of Urban Ecology* (2016). The United States – a dominant region for ecological research over the last century – has two urban locations included within its Long Term Ecological Research (LTER) sites: Central Arizona-Phoenix and Baltimore, both of which have contributed to a range of studies (e.g. Lin and Grimm, 2015). What would once have been considered a relatively marginal area of scientific curiosity within the broader sphere of ecology is now a coherent and respected arena of investigation (Wu 2014).

Once an emerging field has been established in the research community, the logical progression is for its instruction to become part of the educational canon, so that current generations of students are equipped to understand and implement the field's findings. The recent publication of a series of textbooks and edited handbooks on the subject (Gaston 2010; Douglas et al. 2010; Niemelä et al. 2011; Francis and Chadwick 2013; Forman 2014; Douglas and James 2015; Parris 2016) suggests demand, or at least the expectation of an undergraduate/postgraduate market. But how well has the growing maturity of urban ecology translated into higher education curricula? This question is investigated here.

In many ways urban ecology is well-suited to make the transition from specialist research field to the university classroom. Most people are born and raised in cities (United Nations 2015), and so their engagement with nature takes place within an urban context (Miller 2005; Sampaio et al. 2018). The majority of universities are located in cities, affording access to a range of urban ecosystems and ecological communities for easy field visits and activities. The educational possibilities of urban environments are well documented (e.g. Russ and Krasny 2017), from semi-natural green spaces (Bratman et al. 2015; Sampaio et al. 2018) to entirely artificial ecosystems such as walls (Kinchin 1988). These allow both instructional possibilities and independent learning, for example through the application of research projects (Bestelmeyer et al. 2015). The increasing application of citizen science initiatives to urban environments highlights their opportunities for acting as open laboratories for experimentation and learning (Cooper et al. 2007; Dickinson et al. 2012). This is further supported by the applied nature of many of the questions explored in urban ecology.

The UK in particular has a strong urban ecology pedigree, with centres of research emerging at various points in Sheffield, Bristol, Birmingham, Manchester and London. Several authors from the UK have written extensively on urban ecology, including significant textbooks or monographs (e.g. Gaston 2010; Francis and Chadwick, 2013; Douglas and James 2015; Rotherham 2017) and one of the earliest and most comprehensive studies on urban ecology came from pioneering work in Sheffield (Gilbert 1989). It may therefore be expected that urban ecology will have effectively transitioned to higher education curricula within the UK.

This paper is concerned with mapping (1) the extent to which elements of urban ecology (across biology, hydrology, soils, climate etc.) are embedded within educational curricula within the UK; (2) which elements are most prevalent and which are under-represented; (3) which subject areas or

disciplines most commonly house urban ecology elements; and (4) if there are geographical and/or institutional patterns in urban ecology education.

2. Methods

To explore how urban ecology education has been incorporated into UK higher education, the entire undergraduate and postgraduate provision of all known UK higher education institutions (HEIs) (n = 147) was reviewed from institutional websites during November-December 2017. Where any undergraduate or postgraduate programmes covering any aspect of biology, ecology, environmental science, environmental management, agriculture, geography or urban planning were determined, the programme information was reviewed to determine any mention of 'urban', 'city', 'cities' and 'built' in the programme, module or course details. Where such terminology was used, the context was then evaluated to establish to what extent elements of urban ecology were incorporated. This was taken to include any of the ecological aspects of urban ecosystems, including urban biota or biodiversity (including urban forestry and urban agriculture), water, climate, soils and pollution. Purely social (e.g. urban geography) or architectural/planning content was not considered, unless there was a specific ecological context (such as the creation/planning of eco-cities or green infrastructure, or teaching on key urban ecological concepts such as urban ecological sustainability or resilience).

If any of the above aspects were incorporated, the following information was collected: (1) educational level (i.e. undergraduate first, second or third/final year, or postgraduate); (2) the broad programme(s) or department(s) that the material was incorporated within; (3) the specific topics covered; (4) whether any field or lab elements were included; (5) whether the content was a dedicated module (e.g. a module broadly on urban ecology or urban environments) or part of a broader module (e.g. a module on ecology that makes reference to urban ecosystems); and (6) the geographical location of the HEI within the UK.

Following scrutiny of available curriculum details, a Google search was also conducted using the terms [HEI name] and "urban eco*" or "urban env*" to detect any sites wherein these terms are used that may have been missed in the detailed curricula survey. In no case did this provide any further educational information beyond that found in the curricula survey, but rather illustrated a few cases wherein HEIs were research active but not teaching in these areas.

3. Results

3.1 Elements of urban ecology found in educational curricula

50 of the 147 HEIs (34%) incorporated some element of urban ecology or urban ecosystems in their educational provision. In most cases, the urban ecology topics covered were part of broader modules, for example on environmental pollution, environmental management or water resource management, rather than modules with an entirely urban focus. However, of the 50 HEIs that taught elements of urban ecology in some form, 18 (36%) had full modules on one or more elements of urban ecology/urban ecosystems, with 4 HEIs having two modules, one having three and one having five (the latter being University of Salford, with an MSc programme dedicated to Ecologies of Cities of which five modules were focused on urban ecology as I have defined it here). One university (University of Lincoln) had an urban ecology module (called 'Urban Ecology') as a core module within its Ecology and Conservation BSc programme, but all other undergraduate urban ecology modules were optional within their programmes.

Of the 50 HEIs teaching elements of urban ecology, 38 (76%) incorporated them within undergraduate programmes, and 30 (60%) within postgraduate programmes. Within the undergraduate programmes (38 HEIs), 10 (26%) taught at first year level, 10 (26%) at second year and 28 (74%) at final year.

There were 127 instances of urban ecology/urban ecosystems topics being incorporated in the curricula of the 50 HEIs. These topics were diverse, and have been grouped into twenty categories as given in Table 1. The most common category included those topics relating to ecological aspects of sustainable cities or eco-cities, which featured in over 16% of instances. This was followed by the categories of urban water and urban climate, with 13% and 10% of instances respectively. Other categories, including those with a more biological focus (urban ecology more broadly, urban biodiversity, urban forestry and behavioural ecology) were below 10%, and several (urban soils, urban entomology, urban geosciences, urban brownfields and urban nature-society interactions) were only mentioned in one instance.

3.2 Subject areas housing urban ecology

Urban ecology education was incorporated within programmes across a range of disciplinary areas, including biology, geography, environmental science, urban planning and architecture, including some quite specific postgraduate degrees. In total there were 80 separate undergraduate or postgraduate programmes that housed urban ecology topics, and which could be effectively grouped into broad disciplinary or programme categories. These are summarised in Table 2. Most urban ecology (30%) is being taught under the umbrella of 'Environment' programmes, particularly environmental science and management (Table 2), with the geosciences (mainly Geography) (24%) being second highest. Life sciences (including Biology, Ecology and Forestry) come next with 20%, followed by planning and design (16%) and sustainability science (10%). It is common for modules teaching components of urban ecology to be optional and shared between programmes (e.g. both biology and geography), and therefore a single module or topic may be studied by students from several disciplinary backgrounds and interests. All programmes incorporating urban ecology topics (e.g. several programmes with access to the same module) are included in the data presented in Table 2.

3.3 Geographical and institutional patterns in urban ecology education

England (39), Wales (4) and Scotland (7) all contained HEIs that taught elements of urban ecology, though not Northern Ireland (Figure 1). Most HEIs in the UK are based in cities, and most of the large cities and towns of the UK contained HEIs that taught elements of urban ecology, including Manchester, Liverpool, Birmingham, Oxford, York, Edinburgh, Glasgow and Cardiff. Of the 22 HEIs in London, only five taught urban ecology topics. Of the 24 Russell Group (research-led, high prestige) universities in the UK, 15 (63%) incorporated elements of urban ecology in their curricula.

4. Discussion and conclusion

The presence of elements of urban ecology within the curricula of 34% of HEIs suggests that the field has become embedded within the educational landscape reasonably well, given its relatively specialist nature; of the 172,878 articles listed in Web of Science by Clarivate Analytics as containing the topic "ecology" (as of 1st Feb 2018), only 6,357 (3.7%) contain the terms "urban" AND "ecology". This is a crude indicator, but suggests that although urban ecology is a small subset of the wider discipline of ecology, it is well-represented in the curricula of associated fields. Urban ecology topics mainly featured in final year undergraduate (74%) or postgraduate (60%) modules, indicating that they are mainly being taught at a relatively advanced level, probably as specialisms that build on

broader foundational environmental or ecological knowledge obtained earlier in taught programmes, and likely incorporating elements of teaching staff research or experience. The presence of some dedicated modules on urban ecology topics may also represent the research specialisms of academic staff teaching those modules, but is also indicative of some tailored programmes that foreground urban ecological issues, perhaps highlighting the perceived importance of understanding urbanisation and the need for more ecological development of cities as the rate of global urbanisation intensifies, especially given its complexity (Pickett and Zhou 2015). The relatively high occurrence of urban ecology topics in the research-led Russell Group universities (63%), higher than the sector average (34%), further supports the transition of the field into teaching provision through the incorporation of staff research specialisms.

It is perhaps not surprising that most urban ecology is being taught under the umbrella of the environmental sciences, as many topics covered bypass or downplay the biological aspects of urban systems, and therefore fall more within the description of 'urban environmental sciences'. Urban sustainability frameworks and their links to more ecologically-friendly or resilient cities fall more naturally within the discipline of environmental science, while the high occurrence of urban hydrology and climate topics in curricula reflect societal concerns with increasing urban risks and impacts associated with, for example, flooding (e.g. Hallegatte et al. 2013) and human health impacts from urban heat island effects (Tan et al. 2010; Jenerette et al. 2016).

These topics are intrinsically linked to ecological aspects of urban systems (particularly the role of vegetation in mitigating or ameliorating effects or impacts), and teaching may include instruction or discussion of this; the level of detail provided on most HEI websites is too limited to judge. Nevertheless, the focus is usually more on the applied nature of solving the environmental problem (flooding, pollution, heat islands) rather than the ecology, and it does seem that there is much greater scope for teaching of the more ecological and biological aspects of urban ecosystems. There is limited evidence for urban-centred teaching of more traditional ecological topics such as population or community ecology, and only a few cases of the occurrence of typical ecological staples such as behavioural ecology and entomology.

Even within the more applied ecological topics, the prevalence of urban forestry and urban agriculture, which are relatively niche areas of urban ecological investigations, reflects the drive for exploration of mechanisms to address the issue of sustainable urbanisation, rather than how cities may be used to explore more fundamental ecological or biological themes. This suggests that the

focus of 'urban ecology' education is either on how ecological considerations can address the problems of urban systems, or how urban systems are interesting (or unusual) for their exceptional ecologies, rather than being places where ecological education can be encapsulated in its entirety. There is perhaps an opportunity for educational development in this respect, and in particular for more rounded teaching of biology and ecology; these are after all fundamental to urban ecosystems. Perhaps the reticence relates in part to the ecological and biological academic communities, who have historically been wary of researching urban areas (Francis et al. 2012).

Particular opportunities for biologists and ecologists exist in the teaching and exploration of important ecological patterns and processes easily observable in cities, including plant community self-organisation (nicely encapsulated in recent discussion of recombinant communities; Rotherham 2017), seral processes, behavioural change in a range of animals, metapopulation dynamics and microevolution to suggest a few; these topics are all found in urban ecology research, and translate well to teaching not just about the peculiarities of cities, but about the topics themselves. Any urban plant survey will find evidence of recombinant communities, comprised of plants from many different origins and with differing resource requirements, and of mixed alien/native provenance (Francis and Chadwick 2013; Rotherham 2017). Brownfield sites and parks show seral development from disturbed ground to semi-natural or plagioclimax states (Schadek et al. 2009; Kattwinkel et al. 2011). Observations or recordings of animals in the field will show behavioural changes, such as in foraging or escape distance (Francis and Chadwick 2012). The possibilities are endless, and cities are important labs for learning about nature, all the more valuable for their familiarity and proximity. Instruction in the urban environment can demonstrate that ecology does not have to exist at a far remove from everyday life, and that there is much to be observed. At a time when engagement with nature is increasingly limited (Miller 2005), highlighting its presence in cities through considered educational efforts seems a worthy endeavour.

It should be noted that this mapping exercise has covered only a snapshot in time, and that the absence of urban ecology from course details does not mean that urban ecology is not covered in any form; but rather that coverage is not significant enough to warrant advertisement of the fact. Ultimately all judgements are made based on available online information, and this varies between HEIs, with some providing much more detail than others. It is therefore considered that this is the best map currently available, and will hopefully encourage the expansion of urban ecology education, particularly within ecological and biological programmes.

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Category	Terms incorporated*	Number of occurrences (% of 127 total)
Urban ecological sustainability	Eco-cities, sustainable cities, ecological footprint	20 (16%)
Urban water	Water management, water security, hydrology, flooding, Sustainable Urban Drainage Systems (SUDS), water infrastructure, blue infrastructure, drainage	17 (13%)
Urban climate	Climate, climate change	13 (10%)
Urban green infrastructure	Green infrastructure, green space(s), ecological networks	11 (8.7%)
Urban pollution	Air pollution, soil pollution, water pollution, water quality	11 (8.7%)
Urban ecology/urban ecosystems	Urban ecology, urban ecosystems	9 (7.1%)
Urban food production	Food production, farming, food security, peri-urban agriculture, vertical farming	9 (7.1%)
Urban environmental management	Environmental management, environmental assessment, planning, engineering, protection	7 (5.5%)
Urban biodiversity	Biodiversity, plants, conservation	6 (4.7%)
Urban ecological resilience	Resilience	6 (4.7%)
Urban landscapes	Landscape ecology, landscape design	3 (2.4%)
Urban ecosystem services	Ecosystem services	3 (2.4%)
Urban forestry	Forestry, woodlands	3 (2.4%)
Urban environmental modelling	Environmental modelling, spatial analysis	2 (1.6%)
Urban behavioural ecology	Behavioural ecology, pests	2 (1.6%)
Urban soils	Soils	1 (0.8%)
Urban entomology	Entomology	1 (0.8%)
Urban geoscience	Geoscience	1 (0.8%)
Brownfields	Brownfields	1 (0.8%)
Urban nature-society interactions	Nature-society interactions	1 (0.8%)

Table 1: Occurrence of different urban ecology topics in HEI curricula, categorised based on terms used. *all terms utilised specifically in urban context. All percentages are rounded to two significant figures.

Discipline/Programme	Programmes incorporated	Number of occurrences (% of 80 total)
Life sciences		*16 (20%)*
Conservation and Biodiversity	Conservation and biodiversity, Wildlife conservation and environmental management, Conservation	3 (3.8%)
Biology	Biology, Bioscience and zoology, Biological sciences	6 (7.5%)
Forestry	Urban forestry, Woodland ecology	3 (3.8%)
Ecology	Ecology, Ecology and conservation	2 (2.5%)
Zoology		2 (2.5%)
Geosciences		*19 (24%)*
Geography	Geography, Geography and planning, Geoscience	19 (24%)
Environment		*24 (30%)*
Environmental science and management	Environmental science, Environmental management, Environmental management and agriculture, Environmental management and sustainable development, Environment economics and ecology, Environmental social science, Sustainable water management	22 (28%)
Water and environmental engineering		1 (1.3%)
Civil and environmental engineering		1 (1.3%)
Sustainability science		*8 (10%)*
Sustainable cities	Sustainable cities, Cities, Global cities, Sustainable urban development, Ecologies of cities, Energy and sustainability, Sustainable engineering	8 (10%)
Planning and design		*13 (16%)*
Landscape architecture	Landscape architecture, Landscape management, Landscapes and urbanism, Architectural design	7 (8.8%)
Urban planning	Urban planning, Urban planning and management, Environment and planning	6 (7.5%)

Table 2: Broad disciplines and programmes including mentions of urban ecology topics within their curricula, based on a desk study of 147 UK HEIs. All percentages are rounded to two significant figures.

Figure caption:

Figure 1: Geographical distribution of UK HEIs with elements of urban ecology in their curricula.